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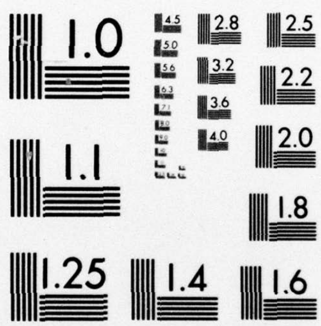
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ARMY MATERIEL COMMAND LABORATORIES
A DESCRIPTION AND OVERVIEW OF CURRENT
MANAGEMENT ISSUES
PMC 73-2

Robert Werner Gruen
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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: ARMY MATERIEL COMMAND LABORATORIES: A DESCRIPTION AND OVERVIEW OF CURRENT MANAGEMENT ISSUES.

STUDY PROBLEM/QUESTION: To describe the AMC laboratory system and to examine issues related to their productivity.

STUDY REPORT ABSTRACT: AMC laboratories provide primary scientific and technical support to AMC and its subordinate commands in the development of military technology and the acquisition of non-project managed materiel. However, the productivity and cost-effectiveness of these laboratories have been repeatedly questioned. This report examines these questions and finds that laboratories make significant contributions to the solution of military requirements. However, laboratory efforts are fragmented over a number of budget categories and program elements which makes it difficult to gain a quantitative feel for their accomplishments. No convincing evidence has been found which decisively proves or disproves that laboratories provide an equitable return for investment. Therefore, much more needs to be done to improve their image. Increased visibility of total laboratory effort in programs and budgets, better marketing of laboratory capabilities and services in reports and the open literature, and increased public information would contribute to this end.

Student, Rank Service	Class	Date
ROBERT WERNER GRUEN, LTC, USA	73-2	November 1973

ROBERT WERNER GRUEN

ARMY MATERIEL COMMAND LABORATORIES: A DESCRIPTION AND OVERVIEW OF CURRENT MANAGEMENT ISSUES

KEY WORDS: FACILITIES EVALUATION RESEARCH LABORATORIES PROJECT REFLEX

BLUE RIBBON DEFENSE PANEL

MANAGEMENT OF AMC LABORATORIES

A DESCRIPTION AND OVERVIEW OF CURRENT MANAGEMENT ISSUES

(Includes) An Executive Summary
of a
Study Report
by

Robert Werner Gruen
LTC USA

November 1973

Defense Systems Management School
Program Management Course
Class 73-2
Fort Belvoir, Virginia 22060

OVERVIEW OF AMC LABORATORIES
AND CURRENT MANAGEMENT ISSUES.

EXECUTIVE SUMMARY

During recent years there has been increasing concern over the dwindling technological lead the U.S. once enjoyed over potential adversaries. This concern, coupled with the necessity for careful allocation of scarce defense resources has led to a series of studies dealing with the management and productivity of defense laboratories. This paper briefly summarizes these studies and examines their impact upon the AMC laboratory system. Organization and missions of AMC laboratories are reviewed and current management issues identified and discussed including the theory, purpose and results achieved by Project REFLEX (Resources Flexibility), SPEF (Single Program Element Funding) and the Lead Laboratory concept. A discussion, analysis and conclusions are presented on the following major issues:

1. The purpose, approach and impact of major laboratory studies are examined. While these studies have identified management issues and have caused institution of management improvements, such as REFLEX, SPEF, designation of lead laboratories and the appointment of an AMC Deputy for Laboratories, they have not convincingly articulated productivity of laboratories.

2. Laboratory contributions to materiel development are considered. The bulk of these are in the development of non-project managed items. While there are some indications of conflict between laboratories and project managers these appear to result from differences in missions and in methods of operation. No management actions are indicated other than continued command interest, insistance that laboratories account fully for customer funded expenditures and a continued program to insure that laboratories and project managers are fully apprised of each other's problems and capabilities.

3. Contributions of laboratories to technology are considered. While it is not feasible to quantify technology, laboratories make vital contributions to the development, coordination and preservation of a technology base for a wide variety of military requirements. Important contributions to technology are not limited to a search for better techniques and materiel, but also include the important function of identifying and eliminating economically unattractive technical approaches to solving military problems.

4. One possible reason for a credibility gap concerning laboratory productivity may result from a surprisingly low level of information concerning laboratory activities and accomplishments within the open literature. Possible means for improving the image of laboratories consist of increasing the visibility of the total laboratory

effort within the AMC program, increased use of magazines and journals to tell the laboratory story and increased use of Service Schools and public information functions as a forum to publicize laboratory activities and laboratory sponsored technological advances.

5. Project REFLEX and SPEF are found to be promising management techniques. Expansion of these programs within AMC and application of similar programs to other Army elements may help ease the strains caused by contracting defense resources.

6

ARMY MATERIEL COMMAND

LABORATORIES

A DESCRIPTION AND OVERVIEW OF CURRENT MANAGEMENT ISSUES.

Presented to the Faculty

of the

Defense Systems Management School

in Partial Fulfillment of the

Program Management Course

Class 73-2

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Mr. J.E. Griffin, Deputy Project Manager for Mobile Electric Power, USAMC.

Mr. Thomas F. Keegan, Staff and Faculty, DSMS.

CONTENTS

ARMY MATERIEL COMMAND LABORATORIES

A DESCRIPTION AND OVERVIEW OF CURRENT MANAGEMENT ISSUES

CHAPTER I. Introduction

1. Purpose.

a. During recent years there has been a growing concern that the technological lead the U.S. once enjoyed over potential adversaries is dwindling fast. In part, this concern has been reflected in statements by DDR&E,[1] the President's Blue Ribbon Panel of 1969[2] and others to the effect that the technological productivity of defense laboratories must be maintained or improved. As a corollary, there has been both explicit and implicit concern of whether new technology developed by laboratories is being applied effectively and timely to ongoing materiel development programs.

b. To gain a better understanding of the contribution of laboratories to technology and the translation of this technology into useful military products or techniques, this study describes selected laboratories and examines issues related to the management of laboratory programs.

2. Methodology.

a. Approach. This study is based upon a literature search employing the Defense Documentation Center and literature readily available through libraries and agencies in the Washington, D.C., and Ft. Belvoir, Va. areas. Unstructured interviews were conducted with selected personnel from Department of the Army, Hq. USAMC, laboratories and with project management personnel resident within the Washington, D.C./Ft. Belvoir area. In addition, some telephonic interviews were conducted with selected personnel at distant locations to clarify specific questions or areas of interest. Paragraph 3 below summarizes issues developed from these sources. The remainder of the study concentrates upon development of an understanding of the AMC laboratory system and a discussion and analysis of these issues.

b. Limitations.

(1) Time. This study is a part time effort in conjunction with a five (5) month course of instruction at the Defense Systems Management School, Ft. Belvoir, Va. This limited the amount of time available for an in depth analysis of a complex subject. Because of time constraints, all discussions concerning laboratories are restricted to Corporate Laboratories directly subordinate to Hq. USAMC and to laboratories subordinate to AMC Commodity Commands.

(2) Classification. This study was restricted to unclassified information sources. Classified data and

information also were excluded from interviews.

(3) Non-attribution. A non-attribution policy was followed during all personal interviews in order to encourage free discussion. Because of this, information and opinions obtained from these interviews have been incorporated into this study without identification or attribution.

3. Issues.

a. One of the leading issues regarding laboratories results from the need for technological competition with potential adversaries and the need to prevent a serious deterioration of our defense posture through technological surprise. While the U.S. at one time enjoyed a clear technological superiority, this superiority has eroded significantly as a result of shifting concentration of resources upon meeting operational commitments in Southeast Asia and an unwillingness to match increased cost of research and development with increased resources. This concern was enunciated by the DDR&E in his testimony of 17 April 1973 to the Senate Committee on Armed Services as follows:

> "...I find it very disturbing that no projection shows that we are holding our (technological) superiority if current trends in the United States and the Soviet Union continue. Each projection independently shows that, to avoid technological inferiority within the next decade, we will have to increase our Defense RDT&E efforts; some of these projections show that substantial increases would be necessary."

In view of these implications, the question arises of whether defense laboratories are making sufficient contributions to the technology base.

b. A second issue concerning laboratories is whether technology developed by them is being productively applied to current development programs. This concern formed the basis of the allegation by the Blue Ribbon (Fitzhugh) Defense Panel that:

> "Overall, the productivity of Defense in-house laboratories appears low compared to the very substantial investments in them. ....They are fragmented along technology lines with limited scope and responsibility."

There was serious objection to these conclusions from many in the R&D community, including the DDR&E Task Group on Defense In-House Laboratories. These objections can be summed up by the following comment which was received during an interview: "How can anyone criticize laboratory programs without having visited a laboratory." However, concern with this subject was later again reflected in the DDR&E's testimony of 17 April 1973, in which he said:

> "The technology base effort is made up of many relatively small projects covering many different areas of science and engineering. This diversity poses management problems:
>
> • How can we be sure these projects are addressing important military problems.
>
> • How can we be sure that a project at one laboratory is not needlessly duplicating some project at another laboratory.

" How can we be sure that results of the R&D effort are eventually applied to needed military systems."

This concern is also evident in the letter of 8 April 1971 from CG, USAMC to his subordinate commanders, project managers and directors of laboratories in which he enjoins them to involve laboratories in development programs for major defense systems on a priority basis, and again in his letter of 18 October 1971 in which he directs that each project manager be provided with an ad hoc laboratory staff member to improve the direct coupling between project managers and the technical community.

c. During the literature search and interviews conducted in preparation for this paper, the questions most frequently raised in relation to these issues were:

(1) In view of the frequent studies concerning laboratories, why are there still questions about their productivity?

(2) How can the productivity of laboratories be described or quantified?

(3) Are laboratories contributing to the solution of the Army's urgent materiel needs?

(4) Are laboratories making substantive contributions to the technology base?

(5) Why is information concerning the capabilities and activities of laboratories so difficult to locate?

4. Abbreviations and Definitions. Abbreviations are introduced within the study whenever they first occur. For easy reference, abbreviations used throughout this paper have been collected and are attached as Appendix 1.

5. Information Sources.

a. An annotated bibliography of background material utilized for this study is at Appendix 2. With minor exceptions, documents utilized for this study were obtained from the Defense Documentation Center, the Defense System Management School Library, from the Office of the USAMC Deputy for Laboratories and the Laboratory Review and Technical Coordination Office in the Office of the Chief, Research and Development.

b. A short summary of recent significant studies, reports and findings dealing with utilization and management of laboratories is attached as Appendix 3.

CHAPTER II. Description of AMC Laboratories

1. Organization. There are two types of laboratories within the AMC. The first consists of "Corporate Laboratories". These laboratories are primarily technology oriented and report directly to headquarters, USAMC, where a Deputy for Laboratories exercises staff supervision over laboratory activities for the Commanding General. The second type consists of "Commodity Command Laboratories". These, while still engaging in activities to further technology, generally have a heavier commitment toward product oriented activities. Commodity Command Laboratories report directly to AMC subordinate Commodity Commands. A listing of AMC laboratories and a summary of their missions and functions is included in Appendix 4.

2. Laboratory Objectives. Almost every source or study group has a different set of laboratory objectives. The most common of these are as follows:

a. Provide military technology not available in industry. Develop novel or new technological approaches toward the solution of recognized military needs. Act as a catalyst to stimulate industrial interest in promising technological innovations.

b. Maintain a government base of technical competence for evaluating technical proposals and contractor performance.

c. Assist in defining Army requirements. Advise user and combat development agencies on the current state-of-the-art applicable to new requirements.

d. Conduct or participate in concept formulation studies for solution of recognized materiel requirements.

e. Evaluate the feasibility of new materiel or systems proposals.

f. Provide services and a production capability for military specialty items and hardware in areas where there is no industrial capability or interest.

g. Provide an in-house capability for emergency assistance or quick reaction R&D support for deployed combat forces.

h. Assist in the technological aspects of threat studies. Evaluate foreign materiel and technological capabilities.

i. Provide continuity in the application of technology to new programs and serve as a memory of past achievements and failures.

j. Provide an interface between the Army and the scientific and technical communities. Assist in the technical education of selected military personnel to increase their understanding of the application and utilization of technology to the solution of military problems.

3. Plans, Programs and Budgets. Basic guidance for planning, programming and budgeting of laboratory efforts is

contained in AR 70-55. Planning of laboratory activities is based upon guidance in the Joint Research and Development Objectives Document, the Army Strategic Objectives Plan, the Army Long Range Technological Forecast, the Catalogue of Approved Requirements Documents (formerly Combat Development Objectives Guide), and more recently DOD Area Coordination (ACP) and Technology Concept Papers (TCP). In addition, laboratories receive annual programming and budgeting guidance through their chain of command. Each laboratory submits a proposed program which is reviewed by its chain of command and eventually results in the issuance of an approved program. One interesting aspect of the formulation of laboratory program is that formal review concentrates upon basic research, exploratory development and non-system oriented advanced development. Laboratory participation in systems oriented advanced development, engineering development and support of deployed materiel is generally negotiated with the customer or commodity manager and justified and reviewed as part of his program. Although a complete breakout of laboratory effort can always be obtained directly from the laboratory and at least summary data for laboratory participation in all program categories can be obtained from the laboratory posture reports,[3,4] the dispersal of laboratory effort within the PPBS causes a loss of visibility and may be a contributor to frequent questions concerning the cost effectiveness of laboratories. An example of the diversity

of laboratory activities is the fund distribution for the Mobility Equipment Research and Development Center (MERDC) shown in Figure 1. This shows that MERDEC in-house obligations of 6.1 and 6.2 funds for FY 73 was only about 20% of its total in-house effort and total inside and outside 6.1 and 6.2 obligations constitute only about 14% of its total program. Hence, it is clear that this laboratory has missions far in excess of those which can be directly identified within the AMC RDT&E program.

FY 73

Funds	Inside	Outside			Total
		Indirect	Other AMC	Other Government	
6.1 and 6.2	5199	8072	565	845	14681
Percentage	35	55	4	6	
Other Direct	8301	8662	1611	1278	19851
Percentage	42	44	8	6	
Reimbursable	6932	7323	-	1000	15256
Percentage	45	48	-	7	
Total R&D	20432	24057	2176	3123	49788
Percentage	41	49	4	6	
O&MA	7043	9485	-	-	16528
Percentage	43	57	-	-	
PEMA	-	9461	-	-	9461
Percentage	-	100	-	-	
Direct Cite	-	29695	-	-	29695
Percentage	-	100	-	-	
Total Program	27475	72698	2176	3123	105472
Percentage	26	69	2	3	

MERDC FY 1973 OBLIGATIONS

Figure 1

4. Management Innovations. A number of recent management actions have been initiated to improve the productivity and responsiveness of AMC laboratories. A summary of these is as follows:

a. The Lead Laboratory Concept. The lead laboratory concept was devised to reduce the possibility of peacemeal approaches and to enhance a coordinated effort for the advancement of specific technologies. A designated lead laboratory is responsible for planning, formulating, coordinating, promoting and managing assigned technology areas encompassing research (6.1), exploratory development (6.2) and, in some cases, non-system oriented advanced development (6.3). Current lead laboratories and respective technology areas are shown in Figure 2.

b. Single Program Element Funding (SPEF). One of the problems related to the effectiveness of in-house laboratories has been the fragmented structuring of laboratory programs under multiple program elements in the 6.1 and 6.2 categories. This created an administrative burden and restricted flexibility of laboratories in moving resources between closely related efforts. In order to eliminate these disadvantages, AMC implemented SPEF at the Missile Systems Laboratory in FY 71. Under this experimental program, 21 projects located in seven program elements were combined into a single program element with the title "Missile Technology". According to the 1972 Summary and Overview of AMC

LEAD LABORATORIES

COUNTERMINE:	MOBILITY EQUIPMENT R&D CENTER
FLUIDICS:	HARRY DIAMOND LABORATORIES
GUIDANCE AND CONTROL/TERMINAL HOMING:	MISSILE SYSTEMS LABORATORY, MICOM
HIGH ENERGY LASER:	MISSILE SYSTEMS LABORATORY, MICOM
HUMAN ENGINEERING:	HUMAN ENGINEERING LABORATORIES
LOW ENERGY LASER:	COMBAT SURVEILLANCE/TARGET ACQUISITION LABORATORIES, MICOM
MATERIELS:	ARMY MATERIELS AND MECHANICS RESEARCH CENTER
NIGHT VISION:	NIGHT VISION LABORATORY, ECOM
NUCLEAR EFFECTS:	HARRY DIAMOND LABORATORIES
VULNERABILITY:	BALLISTIC RESEARCH LABORATORIES
SOLID MECHANICS:	ARMY MATERIELS AND MECHANICS RESEARCH CENTER
CAMOUFLAGE:	MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT CENTER
MATERIELS TESTING:	ARMY MATERIELS AND MECHANICS RESEARCH CENTER
BALLISTICS:	BALLISTICS RESEARCH LABORATORIES
ENERGETIC MATERIELS:	FELTMAN RESEARCH LABORATORY

Figure 2

Laboratories, this program has been highly successful in that it enabled the Director to improve allocation of resources in accordance with changing priorities. Based on the success at MICOM, AMC reduced the detail of its program guidance from the subtask and work unit level to the project level for all laboratories. It further has initiated action to apply SPEF to some additional laboratories. One of the requirements for obtaining authority to implement SPEF is that the laboratory must demonstrate a management capability to the CG, USAMC and must obtain his approval of a long range plan which establishes priorities and provides guidelines for the allocation of both in-house and out-of-house resources to the solution of recognized requirements. Since authority for SPEF is a highly desirable goal for all laboratories, this has caused much increased attention to the establishment of better, coordinated R&D planning. As an example, in its drive for getting authority for SPEF, MERDC, for the first time in its history, is preparing a comprehensive, coordinated 10 year R&D plan.

c. Resource Flexibility (Project REFLEX). Project REFLEX was initiated as a result of a 1969 study which indicated that work load and program requirements have little relationship to the manpower allocation process.[5] This phenomenon was found particularly troublesome for laboratories which had relatively constant workloads and personnel levels during the Vietnam buildup but now were expected to share in

the overall DOD personnel reductions. Initially designed as an experiment, the objective of project REFLEX was to achieve a better correlation between manpower and workload by permitting selected laboratory directors to establish their own manning levels within the constraints of their program and fiscal guidance. There was some concern that removal of manpower ceilings would tend to cause a large increase in manning levels, salaries and a significant shift of out-of-house to in-house managed effort. After two years of operation at four laboratories, this concern has not materialized. There were no significant effects upon personnel levels and the distribution of in-house research, while average salary levels have slightly decreased. Further, a better capability to match the right people with the right job is being reported. Based upon these successes, the CG, USAMC is expanding the REFLEX program to other laboratories and is experimenting with applying it to other activities.[3] Because it provides an incentive for maintaining a balance between programs and available resources, REFLEX appears to be an excellent tool for overcoming the general problem of eliminating personnel while leaving the mission unchanged which is characteristic during periods of shrinking defense resources. This concept might well be one which should be considered in some form for other Army programs including the operation of posts, camps and stations, reduction of overhead functions (in particular headquarters elements), and

perhaps even for combat forces.

d. In-House Laboratory Independent Research (ILIR). ILIR, or sometimes known as the director's fund, is established under the provisions of AR 70-55. Its main purpose is to provide a means to laboratory directors to pursue unprogrammed promising research. Another objective is to generate an additional incentive for scientists and engineers to maintain and increase their competence by doing original work in areas suited to their talents. The only restriction on the use of ILIR is that it must be used to support the work of in-house personnel. It has been used for exploring new ideas, for retraining and upgrading of personnel and for initiating worth while unprogrammed research.

e. Support to Project Managers. As indicated in paragraph 3b above, the transfer of new technology to major materiel development programs is a primary concern of laboratory management. This concern is evident from the personal interest of the CG, AMC, in this subject. To improve this transfer the following programs have been implemented:

(1) Project Managers have been directed to involve laboratories more in their high-priority, high visibility programs. Similarly, the laboratories have been directed to respond on a priority basis.[6]

(2) Ad hoc laboratory representatives with a basic knowledge of the capabilities of the entire laboratory system were assigned to each project manager. These repre-

sentatives participate in deliberations, reviews and briefings of project managers in order to provide direct advice on the capabilities of laboratories and to serve as a point of contact with them.[7]

(3) Laboratory directors are required to participate in Reviews and Command Assessments of Projects (RECAP).

(4) An annual technology review is presented by lead and associated laboratories to the CG, AMC and his major subordinate commanders. These reviews, along with the annual RDT&E Program Review, enable these commanders to remain fully apprised of technological advancements and innovations with potential system applications.

(5) Annual Laboratory Posture reports which describe the capabilities and major tasks undertaken by laboratories are being prepared and distributed to project managers.

CHAPTER III. Discussion and Analysis

1. General. This chapter discusses and analyzes laboratory issues identified previously by considering each of the issue related questions in paragraph 3c, Chapter II.

2. Consideration of Issues.

a. Laboratory Studies.

(1) The question of whether the productivity of laboratories is commensurate with the quite considerable resources invested in them has been raised by the Congress.[13] It has been raised directly or indirectly by every Secretary of Defense, who during the past twelve years has remained in office long enough to ask it. It has been raised by the Bureau of the Budget,[9] and recently it has been raised bluntly by the Blue Ribbon Defense Panel (BRDP).[10] In an attempt to find explanations for the technical and cost problems associated with major development programs, this panel apparently could not identify any significant contributions being made by defense laboratories to the solution of these problems. It concluded that defense laboratories are less productive then they ought to be in relation to the considerable resources invested in them (see paragraph 3, Appendix 3). Although these findings have been belittled by some based upon the premise that the BRDP failed to conduct a first hand investigation of laboratories, the question is still very much alive. Considering that based upon 1972 figures, DOD is investing 2.3 billion and the Army is investing 800

million annually for in-house RDT&E,[12] this amounts to a significant portion of the total RDT&E budget. Hence, with progressively increasing pressure on the defense budget from reduction of appropriations, inflation and much increased manpower and support costs, continued scrutiny of in-house RDT&E is inevitable until Defense laboratories can clearly demonstrate that they are cost-effective. A clear indication that the question is still alive was again demonstrated by the DDR&E in his recent testimony to the Senate Armed Services Committee when he found it expedient to raise the question himself and then to proceed to assure the committee that the DOD is still working on it.[1]

(2) As is evident from Appendix 3, the normal response to high level questions concerning laboratory productivity is a study. An analysis of these studies shows that they all have a great deal in common. First, they rely heavily upon scientific/technical personnel from within OSD, the Services and from laboratories for their staffs, or for their information. In many cases key personnel or consultants consist of the same people from one study to the next. This is probably why one finds a great deal of copying of ideas, data and conclusions, sometimes to the extent of word for word repetitions. This makes these studies somewhat vulnerable to charges of parochialism. All of the studies attempt in one way or another to present evidence that laboratories are making substantive contributions. They contain

long lists of projects and accomplishments, usually refer to some well known achievements such as the development of the first electronic computer at BRL and then frequently concede that perhaps more should be done to increase participation of the laboratories in the materiel acquisition process and to insure transfer and application of the technology base to satisfy military needs. Thus all of the studies appear to have difficulty in articulating laboratory productivity. Certainly, they have not succeeded in stopping the productivity question from being raised from time to time. Finally, all the studies conclude, directly or indirectly, that the way to improve productivity of laboratories is to implement management improvements which provide more freedom of action and authority to the laboratory directors in the technical direction and allocation of laboratory resources, and to free them from bureaucratic constraints. As a matter of fact, most of the recent management innovations discussed in paragraph 4, Chapter II, (i.e. the lead laboratory concept, SPEF, Project REFLEX, ILIR, and detailing of ad hoc laboratory representatives to project managers) resulted from recommendations developed by these studies. Thus, while these studies have not satisfied questions concerning the cost-effectiveness of in-house RDT&E activities, they have focused attention upon management issues.

b. Description and Quantification of Laboratory Productivity.

(1) Laboratories engage in a wide variety of activities including the following:

(a) Supporting research in the development of new techniques and materiel.

(b) Production and maintenance support for low volume or critical materiel items.

(c) Development of individual equipment for the combat soldier.

(d) Human engineering.

(e) Maintenance of a technological and industrial mobilization base.

(f) Logistic support, maintenance and reliability engineering.

(g) Technical advice and assistance to other Army elements.

(h) Technical evaluation of contractor performance.

(i) Quality control and testing of new materiel.

(j) Basic research and exploratory development to exploit new technology.

(k) Guiding industry in the conduct of useful research for the solution of military requirements.

(l) Value analysis and engineering.

(m) Identification of unprofitable or ineffective technical ventures and approaches.

(n) Engineering support for deployed equipment and materiel.

(o) Preparation of technical packages and technical supervision of development and production contracts.

(2) The wide variety of laboratory activities provides an indication of why laboratory productivity has been controversial. The output of laboratories is simply not measurable in terms of a product produced or a service rendered. Measuring this output is further complicated by technical specialization of laboratories. For example, it is difficult to compare the effectiveness of one organization which specializes in the design and production of ballistic weapons and associated equipment with one which principally engages in development and application of human engineering techniques. Sometimes attempts are made to compare laboratory productivity to that of industry. However, this comparison also soon brakes down because industry does not have to prove to anyone that what it does has utility. In the final analysis, its productivity is measured by whether it can show a profit to its stock holders. It is evident that until some measure of effectiveness can be found for what laboratories do, their productivity will remain a topic of uncertainty. Perhaps recent developments in the application of utility theory to the quantification of uncertain events having different units of measure provides a possible approach

to obtaining a measure of the worth of laboratory endeavors. However, since utility theory depends a great deal upon the quantification of judgement and because of the complexity arising from the large range of laboratory activities, much work and research would be required before such an approach would find acceptance.

c. Contributions to Materiel Development. Because of their diverse nature and the requirement to maintain a technical capability over a wide spectrum of technology, the active participation of laboratories in the development of usable products and end items of equipment is generally limited to non-major defense systems, i.e. to relatively small and short duration projects. As indicated in Inclosure 4, the AMC Corporate Laboratories concentrate upon general technology areas. Materiel development activities are generally conducted in support of projects assigned to other AMC commands or to provide quick reaction support to deployed combat forces. The commodity command laboratories on the other hand constitute the technical arm of their parent units and execute technical and materiel development programs, other than project managed items, assigned to these commands, either by undertaking in-house development programs and/or by managing the out-of-house effort. Support for project managers is accomplished on a customer funded basis. In general, laboratories are heavily involved in major programs during the system definition and validation phases

where they participate in studies and evaluations and conduct exploratory and advanced development in support of the program. However, once a development contract for a major system has been awarded to industry, laboratory participation drops sharply, in part because they do not have the staffs to get involved in large scale programs, but also because contractors frequently resist "meddling" by laboratories in their business. While the CG, USAMC, has established a policy for laboratories to become more deeply involved in solving problems associated with major development programs,[6] laboratories have difficulty doing this on a large scale, unless such participation has been planned ahead of time and they have been able to stay abreast of the program. When laboratories are called upon to bail major development projects out of unforeseen difficulties, these problems are usually far advanced and an extraordinary effort is required for the laboratory to catch up technically with what already has transpired on the project. In addition, the diversion of resources to the solution of unprogrammed effort is disruptive and frequently can only be done at the expense of support for other projects. The difficulty of laboratories in supporting project managers is also reflected in the Smith Study[8] which is summarized in Appendix 3. Although this study indicates no predominant reasons inhibiting the relationship between project managers and laboratories, it lists a considerable number of factors contri-

buting to resistance by PM's for using them. These reasons can be grouped into three general classes. The first relates to the lack of control over laboratory response because of competition from other projects and from regularly programmed laboratory effort. The second relates to the inability of laboratories to provide a quick technical response to unanticipated development problems, and the third consists of a collection of miscellaneous factors. Discussion with project managers and project personnel indicates that these observations are still valid. Some additional problems cited concerning cooperation between PM's and laboratories were that PM's at times have difficulty in getting laboratories to differentiate between adequacy and perfection, both in regard to performance achievement and to testing, and that laboratories are notorious for schedule overruns. Diversion of project funds for other purposes was also cited as an occasional problem. However, the lack of uniformity of difficulties experienced by project managers from the utilization of laboratories seems to indicate that many of these problems are attributable to personalities rather than to systematic causes. It also was noted that uniformly, PM's and their representatives acknowledged that at times laboratories provide vital service. The representative of one PM responsible for a family of equipments indicated that he was totally dependent upon a laboratory for his RDT&E because it is the only agency available which

maintains an overall and continuous technical capability over the entire spectrum of his project. Although he recognized the superiority of industry in the field of production, due to its sporadic interest in the RDT&E aspects of his product, no industrial source is able to match the technical capability of the laboratory. Also, the laboratory provides a vital service by performing technical evaluations of many unsolicited proposals received by the PM.

d. Contributions to Technology. As with laboratory contributions to materiel developments, it is difficult, if not impossible, to establish an overall measure of performance for this area. However, there are many examples of significant contributions which can be easily obtained from the references in Appendix 2 and other sources. There are some areas in which the laboratories are the only current custodians of existing technology. Prominent examples of this are warheads, fuzes, night vision devices, ballistics, and development of medium and large caliber guns. The development of new techniques and innovations is not necessarily the most important contribution of laboratories for application of technology to military requirements. One important service performed by laboratories is that they provide an institutional memory for past accomplishments and failures. This assists in identifying potential sources for solutions to new problems. In view of the high mobility characteristic of military personnel, the continuity provided by labora-

tories to the management of the technology base is a function of the highest importance. Since technology frequently leads the formulation of explicit materiel requirements, laboratories serve as a connecting link by directing and guiding research toward meeting imprecisely defined needs and by influencing requirements to take advantage of new technology. Since avoidance of costly technical difficulties and schedule delays are causing development programs to become increasingly adverse to technical risks, laboratories also are playing an increasingly important part in validating the state-of-the-art through exploratory and non-system related advanced development.

e. Visibility of Laboratory Activities. One of the surprising aspects concerning this study was the difficulty experienced in locating information concerning laboratories and their activities. There is very little information located in libraries and little appears in magazines and journals. The unclassified information concerning laboratories obtained from a literature search of the Defense Documentation Center (DDC) proved discontinuous, out of date and provided a relatively poor overview of the field. In the case of the Missile Command, which is highly respected within the R&D community and which is reputed to be conducting highly significant work in a number of fields, the general literature showed that everything about it except its name seems to be classified. The most useful literature and data

eventually was located at HQ., USAMC, at the Office of the Chief, Research and Development and at laboratories themselves. This difficulty in obtaining information may be one of the reasons why the question of laboratory productivity comes up so often. There are indications that some actions are being initiated to cope with this problem. One of these is an annual laboratory posture report which has been initiated by AMC. As of this time, however, this report seems to have a relatively restricted circulation. In addition, it suffers somewhat from excessive bulk. Other actions consist of high level command interest within AMC which has resulted in much increased participation of laboratory directors in project management reviews and the appointment of the ad hoc laboratory representatives to provide assistance to project managers. However, responses from laboratory and project management personnel concerning the effectiveness of these measures have been either negative or non-committal. From these indications it would appear that the image of laboratories could be greatly enhanced by increased marketing of their capabilities and achievements through the use of journals, magazines, and publications made available through the DDC and libraries. There is also some question of whether laboratories present their case sufficiently to the remainder of the Army. While in the 1950's and early 1960's, briefings of what's new in RDT&E were common at Service Schools and during public

displays conducted at various Army posts, these seem to have been severely reduced or even eliminated. It is not clear whether this resulted from a separation of the combat development process from Service Schools or from shortened training cycles to support urgent needs. The merging of the combat development function with the Training and Doctrine Command (TRADOC) may provide some unique opportunities to increase the dialogue between the R&D community and the rest of the Army and to increase consciousness of the RDT&E role by increased use of RDT&E presentations and displays at Service Schools and Army public relations functions.

CHAPTER IV. Conclusions

1. Summary Findings.

a. This study has attempted to answer some questions concerning the effectiveness of AMC laboratories in contributing to the maintenance of military technological superiority and to satisfying urgent current materiel needs. Identification and analysis of the issues has proved difficult. On one hand it is clear that there is serious doubt on the part of those responsible for the allocation of scarce resources that laboratories provide a sufficient return for resources invested in them. On the other hand, those involved with laboratories are convinced that laboratories are providing a service vital to the national defense. While there are indications that laboratories accomplish a great deal more than the record shows, neither those who question nor those who believe that laboratories are providing an equitable return on investment can back their position with decisive evidence.

b. Although the complexity and variety of activities carried out by laboratories makes it difficult to establish simple quantitative measures of productivity, laboratories provide a vital service in the development, maintenance and application of military technology. While their visibility in glamorous, high priority, high cost programs is low, they conduct or manage a large volume of supporting technology required for the development of major weapon

systems and play a key role in the development, modernization and acquisition of the multitude of materiel items which do not qualify for major weapon system status. By maintaining close contact with users of military equipment on one hand and with industry on the other, they form an indispensible function of coordinating and marrying technological capabilities with military needs.

c. Project REFLEX and SPEF are proving to be effective management techniques. By allowing the laboratory director latitude to adjust personnel levels to tasks and work load, both the morale and effectiveness of the work force appears to have improved. No significant shifts have occurred in in-house vs. out-of-house effort as predicted by some, and both the number of personnel and the grade structure have decreased slightly. The apparent success of this program suggests that the REFLEX type approach may be useful for other types of organizations which are faced with a reduction of resources. The consolidation of work units and projects under a single program element as part of the SPEF program has provided laboratories more flexibility in adjusting resources to match changing priorities and to better tailor resources to the needs of projects. A beneficial side effect has been that procedures required for authorization of SPEF have resulted in improved planning.

d. There is no concrete evidence that laboratories are generally deficient in providing support to project

managers, however, there are some indications of conflict. In most cases these conflicts seem to be caused by personal biases and by differences in basic missions and methods of doing business. In view of the rather limited laboratory effort in support of major programs, no management actions are indicated other than to continue a mutual education program between laboratories and project managers and to insure strict accountability of customer funded activities.

e. While during the last 15 years many studies concerning laboratories have resulted in significant management improvements, they have not been successful in convincingly documenting and projecting laboratory productivity. With the probable continued pressure upon the R&D community to prove its worth, much more needs to be done to provide visibility to laboratory accomplishments. Further development of the laboratory posture report to portray a concise but convincing picture of significant accomplishments and capabilities, more articles concerning laboratory activities in journals and magazines and increased use of Service Schools and Army public affairs functions for increased dialogue are possible methods for improving the laboratory image.

f. Although with the expenditure of some effort it is possible to gain an understanding for the total laboratory program, there is limited visibility of laboratory activities within the overall AMC program for all but basic,

exploratory and non-system advanced development. The Department of Defense In-House RDT&E Activities report prepared for DDR&E by OCRD is an attempt to overcome this limitation. However, providing more visibility for the total laboratory effort within the AMC program would not only reduce the necessity for this report, but would also provide a better base for portraying the productivity of laboratories to the DOD, to other government agencies and the Congress.

2. Suggestions for Additional Research. While this study provided an overview of a limited portion of the Defense laboratory system, there is considerable opportunity for additional investigation to gain a better understanding of laboratory management and the cost-effectiveness of in-house RDT&E. The following areas are considered fruitful for further study:

a. Analysis of the management and productivity of a single laboratory.

b. A more detailed study into methods for improving the visibility of total laboratory efforts.

c. A comparison of the utilization, management and the effectiveness of laboratories within the various Services. Such a study might lend itself to a group effort by a student from each Service.

d. The application of utility theory for measuring laboratory productivity.

APPENDIX 1

ABBREVIATIONS

AMC	Army Materiel Command
ACP	Area Coordinating Papers
ADP	Automatic Data Processing
AMMRC	Army Materiels and Mechanics Research Center
AMRDL	Air Mobility Research and Development Laboratory
AR	Army Regulation
AVSCOM	Aviation Systems Command
BRL	Ballistic Research Laboratories
CRD	Chief of Research and Development
CSC	Civil Service Commission
DDR&E	Director of Defense Research and Engineering
DDC	Defense Documentation Center
DSMS	Defense Systems Management School
ECOM	Electronics Command
HDL	Harry Diamond Laboratories
HEL	Human Engineering Laboratories
LWL	Land Warfare Laboratory
ILIR	In-House Laboratory Independent Research
MICOM	Missile Command
MERDC	Mobility Equipment Research and Development Center
OCRD	Office of the Chief of Research and Development
PM	Project Manager
RECAP	Review and Command Assessments of Projects

REFLEX	Resource Flexibility
SPEF	Single Program Element Funding
TACOM	Tank and Automotive Command
TCP	Technology Concept Papers
TRADOC	Training and Doctrine Command
TROSCOM	Troop Support Command
USAMC	United States Army Materiel Command

APPENDIX 2

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13. Donald M. McArthur, ODDR&E, 2 April 1968. Effective Use of Laboratories. A management analysis memorandum containing Congressional testimony concerning utilization of DOD Laboratories to the House Subcommittee on Science and Astronautics, including introductory remarks by Subcommittee Chairman Mr. Daddario and a memorandum by Mr. E.M. Glass concerning DOD Actions to improve the effectiveness of Defense laboratories.

APPENDIX 3

STUDY SUMMARIES

This appendix summarizes the purpose and findings of major studies dealing with the organization, functions and productivity of Defense laboratories.

1. Task Force 97 (TF 97). When Mr. McNamara became Secretary of Defense in 1961, he posed 120 questions to facilitate the formulation of his policies. TF 97 was formed to answer the 97th of these which asked for suggestions to improve operations of in-house laboratories. The task force was formed at OSD level. Through many interviews and visits to laboratories, it focused upon the quality of work being performed, working conditions at laboratories and upon factors which influence the quality of personnel attracted to and retained within the laboratory system. The task force issued a report in October 1961 which, among other things, concluded that clearer lines of technical management responsibility were needed, that greater authority should be given to laboratory directors, administration of laboratory programs should be simplified, and that personnel policies should be adjusted to provide higher incentives to the highly technical personnel required to operate an effective laboratory RDT&E program. In March 1963, DDR&E reconvened a portion of the task force under the title of Task 97 Action Group with the mandate to definitize and coordinate

actions required to achieve the strengthening of laboratories as recommended by TF 97. Major actions resulting from TF 97 and the Task 97 Action group are as follows:

a. Increased use of P.L. 313 and more liberal application of Civil Service Commission (CSC) guidelines to permit better compensation rates for top-level technical personnel.

b. Establishment of a Laboratory Directors' fund to support promising, unscheduled independent in-house research with only after the fact review by higher authority.

c. Delegation of increased responsibility for effectiveness of in-house laboratories to the assistant Secretaries for R&D of all the Services.

d. Experimental block or core funding for research and exploratory development at some Air Force laboratories. Under this concept laboratories have greater latitude for adjusting effort and reprogramming financial resources among laboratory projects.

2. Bell Committee.[9] This committee was organized in 1962 under the sponsorship of the Bureau of the Budget to investigate contracting procedures and management of government sponsored research and development. In the process of its deliberations it also addressed in-house laboratories. Among its findings are that there is compelling evidence that managerial arrangements for many government operated research and development facilities are cumbersome and

awkward. This committee took much of its input from TF 97 and reinforced the recommendations that more authority needs to be delegated to research laboratory directors and that they should be given more latitude in making personnel decisions and in controlling funds. It further recommended elimination of excess layers of supervisory management, coordination and reduction of administrative and fiscal reviews, and assignment of major research rather than a multiplicity of narrowly defined tasks.

3. Blue Ribbon Defense Panel (BRDP). The BRDP, or Fitzhugh Panel, conducted its investigations and deliberations in 1969 and 1970 under a mandate from the President to study and make recommendations for the reorganization and improvement of the Department of Defense. This panel questioned the productivity of laboratories in relation to the resources invested in them. It suggested that more systematic organization along technology lines, consolidation of laboratories and centers and better alignment of laboratory work with the solution of normal (i.e. current) problem areas are badly needed. It cited rigid and arbitrary personnel policies, inflexibility of personnel assignments, and a possible conflict of interest between in-house work and management of contracts as areas requiring attention.

4. Task Group on Defense In-House Laboratories (Glass Study Group).[10,11] This study group was formed to identify actions and make recommendations for responding to the

Defense Blue Ribbon Panel report. While under the sponsorship of OSD, the group drew heavily upon scientific and technical personnel from within and without DOD. It reviewed past analyses and determined that the Blue Ribbon group had been deficient in that it had formed its opinions without the benefit of visits to any Defense laboratories. Accordingly, much of the Glass group's effort was directed toward field visits and investigations of laboratories and their customers. The task group found that, in general, the Defense in-house laboratories do an excellent job of developing military technology and represent a valuable resource of technical expertise, advice and field support. However, the role of in-house laboratories in the systems development area are frequently vague and poorly defined and are not fully exploited. With major responsibility for systems development resting in project managers and directors of system program offices, the laboratory frequently is relegated to an advisory role, and often does not get called upon until after a program gets into trouble. Such lack of direct involvement limits the ability of laboratories to give sound, useful, and timely advice and contributes to fragmented laboratory support for systems development. The report concludes with a recommendation that there should be greater laboratory involvement in systems development over greater periods of time. The report further reinforces once more many of the recommendation of earlier study groups

which in general suggest that laboratories should be given greater authority over their programs, more freedom in matching materiel and personnel resources with tasks at hand and that they should be protected from inflexible administrative requirements, frequent inspections, and remote meddling with the details of their work.

5. <u>Analysis of Project Management Control of Development Performed by In-House Laboratories.</u>[8]

a. This study consists of a doctoral thesis by Col. Joseph Smith and does not necessarily reflect any official Defense Department view. A brief review of this study is included here because, as far as could be determined, it is the only one which attempts to review laboratory involvement from the project manager's point of view. The results of this study were based upon studies, interviews and responses to structured questionaires from 19 project managers. While responses from projects were by no means uniform, some of the reasons most frequently cited as mitigating against or unfavorably influencing the relationship between project managers and in-house laboratories in order of priority were:

(1) Lack of available, qualified manpower to provide an adequate response to an urgent current need. Reluctance to name project officers with known capabilities and changing them when required by the circumstances.

(2) Long lead time to acquire additional manpower or special equipment needed for a task.

(3) Competition from other projects or regularly programmed laboratory R&D effort causing an inability to control laboratory work priorities.

(4) Inflexibility of laboratories in responding to urgent needs within time and resource constraints.

(5) Mediocre laboratory technical capability. This probably is closely related to lack of the right kind of manpower cited in a above.

(6) Excessive overhead charges.

(7) Tendency of laboratories to look for problems rather than solve them.

(8) Administrative difficulties.

b. Other factors cited as influencing the relationship between program managers and laboratories were:

(1) The almost sole source nature of laboratories and command interest in them strengthens their bargaining position in negotiating tasks. In addition, the absence of a firm legal agreement, like a contract, permits renegotiation and thus introduces uncertainty into the project manager's program.

(2) Laboratories set their own priorities, guidelines and standards. Hence they are difficult to supervise. (While it is normal practice to use laboratories for exercising technical supervision over contractors, the reverse would hardly be an acceptable alternative.)

(3) Laboratories frequently have archaic and

non-uniform management information systems.

(4) Development tasks given to and accepted by laboratories and control over them is permissive. While regulations provide a strong influence on control methods with contractors, they are weak on methods for use with in-house laboratories.

APPENDIX 4

ARMY MATERIEL COMMAND LABORATORY SYSTEM

The Army Materiel Command has two types of laboratories. The first of these comprise the Corporate Laboratories. These report directly to the Commanding General and operate under the staff supervision of the AMC Deputy for Laboratories. The second type consists of Commodity Command Laboratories. These report to and are administered by the Commodity Commanders. Laboratories in many cases have evolved from combinations and recombinations of separate research facilities as a result of changing missions, functional grouping and for administrative economy. Other AMC RDT&E activities such as range support and testing activities under the Test and Evaluation Command are not considered as laboratories for the purposes of this report. A brief summary of the composition, location and mission areas of AMC laboratories is as follows:

1. Corporate Laboratories.

a. Ballistic Research Laboratories (BRL), Aberdeen, Maryland. Conducts research and exploratory development in sciences and technologies necessary for conceiving, designing, developing and evaluating weapon systems. Conducts applied research in interior, exterior and terminal ballistics and in target acquisition. Performs supporting research in relevant areas of mathematics, physics, chemistry, solid

mechanics, fluid dynamics, kinetics, molecular physics, combustion and detonation, and nuclear weapons effects. Conducts system reliability studies.

b. Human Engineering Laboratories (HEL) Aberdeen, Maryland. Performs human-factors research to determine capabilities and limitations of the human being with regard to his equipment and environment. Conducts studies on the effect of vibration, noise and pressures associated with weapons and vehicles. Assists project managers and commodity commands in design of materiel which can be effectively operated and maintained in combat by soldiers of average intellect and training.

c. Army Materiels and Mechanics Research Center (AMMRC), Watertown, Massachusetts. Conducts basic and applied research in metals, armor, ceramics and other materiels. Coordinates the total AMC materiels and materiels process research program.

d. Harry Diamond Laboratories (HDL), Washington, D.C. Conducts RDT&E on influence, time and command fuzing; target detection and signature analysis; target-intercept phase of terminal guidance; weapon-system synthesis and analysis for fuzing; counter-counter-measures, nuclear effects and severe mechanical environments; fluerics; instrumentation and simulation; components and materiels. Conducts limited production of fuzes, and provides related industrial and maintenance engineering.

e. Land Warfare Laboratory (LWL), Aberdeen, Maryland. Provides centralized R&D activity with a quick-reaction capability for meeting Army operational requirements related to active land warfare, particularly to war of low intensity in underdeveloped and remote areas. Generates new ideas for materiel items to improve the effectiveness of military personnel committed to limited warfare action.

2. Commodity Command Laboratories.

a. Armaments Command (ARMCOM). This command has been formed by merging the Munitions Command and the Weapons Command. ARMCOM is therefore assuming command of all laboratories indicated below. Some merging of these laboratories and/or realignment of their functions is therefore likely to occur.

(1) Edgewood Arsenal Laboratories, Edgewood Arsenal, Maryland. Conducts R&D on chemical agents, munitions, chemical/biological protective material, aerosol physics, smoke, incendiary and non-electric anti-surveillance techniques. Conducts research in conjunction with the Army Medical Service on defensive aspects of chemical and biological warfare. Provides procurement, production, and maintenance engineering on chemical weapons as required. Coordinates and evaluates chemical aspects of all AMC materiel programs.

(2) Frankford Arsenal Laboratories, Philadel-

phia, Pa. Operates commodity center for small-caliber munitions, propellant activated devices, explosives, pyrotechnics and tracers. Conducts RDT&E related to optical materiel, metallurgy of non-ferrous and reactive metals, materiels degradation, corrosion and its prevention, mycological deterioration and electrochemical coatings, power-transmission fluids for small control mechanisms, and miniaturized ammunition. Conducts research in artillery shell metal parts, cartridge cases, and mechanical timing devices, multi-purpose test equipment, fire control equipment and LASER countermeasures.

(3) Picatinney Arsenal, Dover, N.J. Operates commodity center for all nuclear and non-nuclear munitions to include mines, grenades, rocket and missile warheads, projectiles and mechanical fuzes; pilot plant for making prototypes; explosive ordnance center; DOD plastics technical evaluation center. Procures all Army nuclear munitions.

(4) Rodman Laboratories (formerly Weapons Laboratory), Rock Island Arsenal, Illinois. Conducts RDT&E and provides support to other agencies in artillery mounts, recoil mechanisms, equilibrators, carriages, loaders and linkers, combat vehicles, turret components such as gun mounts, recoil mechanisms, elevating and traversing mechanisms, power controls, stability system (essentially all turret components except cannon, fire-control and communications equipment); secondary armament for combat and tactical

vehicles, individual weapons; magazines; grenade launchers; aircraft armament subsystems (gun); spotting weapons; mounts and pads for mission weapons; clips and links; linkers and delinkers; loaders, hand carts, armsracks, target materiel training devices (except aerial drones); and associated equipment.

(5) Benet Weapons Laboratory (formerly Watervliet Arsenal), Watervliet, New York. Conducts RDT&E for mortars, recoilless rifles and tank, artillery and air defense cannon above 20 MM. Develops cannon assemblies such as breech mechanisms, muzzle devices, bore evacuators scavengers and auto loaders. Conducts basic and applied research in manufacturing techniques for these items.

b. Aviation System Command (AVSCOM). This command controls the Air Mobility Research and Development Laboratory (AMRDL), Moffat Field, California, which conducts RDT&E on low speed aeronautics, aeronautical propulsion, aircraft systems, air mobility support systems, aeronautic structures and in aerodynamics.

c. Electronics Command (ECOM). This command exercises command and control over six laboratory activities, as follows:

(1) Electronics Warfare Laboratory, Ft. Monmouth, New Jersey. Performs research in all fields related to military electronics. Develops new materiels, techniques and designs for components, equipment and systems for commu-

nications, automatic data processing, surveillance, avionics, electronic warfare, meteorology and related fields.

(2) Night Vision Laboratory, Ft. Belvoir, Virginia. Conducts research in image intensification, infrared technology, thermal sights, and night vision technology. Provides RDT&E support to Army and other Service materiel developers with a requirement for applications of night vision devices.

(3) Atmospheric Sciences Laboratory, White Sands, New Mexico. Conducts research in atmospheric sciences and RDT&E of meteorological techniques and equipment. Provides support to upper atmosphere and sounding rocket experiments.

(4) Avionics Laboratory, Eatontown, New Jersey. Conducts RDT&E in Army Aviation electronics including navigation landing, communications, environment sensing, control theory and aircraft antennas and instrumentation. Conducts airborne systems installation and test systems engineering.

(5) Communications Automatic Data Processing (ADP) Laboratory, Ft. Monmouth, New Jersey. Conducts RDT&E on ADP and ADP related communications to include radio, telephonic, telegraphic and facsimile techniques, data storage, communications security, electromagnetic compatibility and communicating processes.

(6) Electronic Technology and Devices Laboratory, Ft. Monmouth, New Jersey. Conducts RDT&E on electronic

materiels, parts, devices and assemblies. Conducts research in the preparation, composition, structure and properties of electronic materiels and related phenomena.

d. Tank and Automotive Command (TACOM). This command operates the Mobility Systems Laboratory, Warren, Michigan, whose general mission is to conduct RDT&E in land locomotion, automotive electronics, materiels, applications and extreme environmental controls, power combustion and propulsion, vehicle suspension (track and wheel systems), and in test equipment and services.

e. Troop Support Command (TROSCOM). This is a new command organized at St. Louis, Missouri. It exercises command and control over the following laboratories:

(1) Mobility Equipment Research and Development Center (MERDC), Ft. Belvoir, Virginia. Conducts RDT&E in the fields of rail, marine and amphibious equipment; construction equipment; bridge and assault stream crossing equipment; materiels handling equipment; fire fighting; prefabricated buildings; waste disposal; power generation; heating and air conditioning; camouflage and concealment; mine warfare; barriers and barrier materiels; intrusion detection; demolitions; water purification; petroleum, oil and lubricants; industrial engineering, land navigation and physical sciences.

(2) Natick Laboratories, Natick, Massachusetts. Conducts RDT&E to provide the combat soldier with equipment and supplies to include rations, clothing, body armor, air-

delivery equipment, containers, field support equipment, military shelters, and health and welfare items.

f. Missile Command (MICOM) operates the Missile Systems Laboratories, Redstone Arsenal, Alabama. Conducts RDT&E in missile guidance systems, propulsion, flight dynamics, aero-ballistics, active and passive seekers, LASER technology and applications, discrimination techniques, gyro-stabilization, target signature, hypervelocity technology and missile structures. Participates in missile system concept formulation and conducts technical evaluation of missile system programs.